

**UTILITY  
PATENT APPLICATION  
TRANSMITTAL**

Attorney Docket No

0135/00315

First Named Inventor or Application Identifier

James Westcott Heater  
Allan Thomas Mays  
John Gillette Davis

Title

UNIVERSAL TOOL FOR UNIFORMLY  
APPLYING A FORCE TO A PLURALITY  
OF COMPONENTS ON A CIRCUIT BOARD

Express Mail Label No.

**APPLICATION ELEMENTS**

ADDRESS TO:

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1. ☒ Filing fee as calculated below.
2. ☒ Specification [Total Pages **[13]**]  
(preferred arrangement set forth below)
  - Descriptive title of the invention
  - Cross References to Related Applications
  - Statement Regarding Fed sponsored R & D
  - Reference to Microfiche Appendix
  - Background of the Invention
  - Brief Summary of the invention
  - Brief Description of the Drawings (if filed)
  - Detailed Description
  - Claim(s)
  - Abstract of the Disclosure
3. ☒ Drawing(s) (35 USC 113) [Total Pages **[5]**]
4. Oath or Declaration [Total Pages **[2]**]
  - a. ☐ Newly executed (original or copy)
  - b. ☒ Copy from a prior application (37 CFR 1.63(d))  
(for continuation/divisional with Box 17 completed)  
☐ DELETION OF INVENTOR(S)  
Signed statement attached deleting inventor(s)  
named in the prior application, see 37 CFR  
1.63(d)(2) and 1.33(b)
5. ☒ Incorporation By Reference (useable if Box 4b is  
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which a copy of the oath or declaration is supplied under Box  
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accompanying application and is hereby incorporated by  
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6. ☐ Microfiche Computer Program (Appendix)
7. ☐ Nucleotide and/or Amino Acid Sequence  
Submission (if applicable, all necessary)
  - a. ☐ Computer readable copy
  - b. ☐ Paper Copy (identical to computer copy)
  - c. ☐ Statement Verifying identity of above  
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8. ☐ Assignment papers (cover sheet & document(s))
9. ☐ 37 CFR 3.73(b) Statement ☐ Power of Attorney
10. ☐ English Translation Document (if applicable)
11. ☒ Information Disclosure ☒ Copies of IDS  
Statement (IDS)/PTO-1449 Citations
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14. ☐ Small Entity ☐ Statement filed in prior application,  
Statement(s) Status still proper and desired
15. ☐ Certified copy of Priority Document(s)  
(if foreign priority is claimed)
14. ☐ Other:

17. If a CONTINUING APPLICATION, check appropriate box and supply the requisite information:

☒ Continuation ☐ Divisional ☐ Continuation-in-part (CIP) of prior application No. **09/030,447**

**18. CORRESPONDENCE ADDRESS**

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Name (Print/Type)	George R. Pettit	Registration No. (Attorney/Agent)	27,369
Signature			Date July 19, 2000

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

John G. DAVIS, et al.

Serial No. To be assigned

Art Unit: Unassigned

Filed:

Examiner: Unassigned

For: UNIVERSAL TOOL FOR  
UNIFORMLY APPLYING A  
FORCE TO A PLURALITY OF  
COMPONENTS ON A  
CIRCUIT BOARD

Atty Docket: 135/315  
[EN9-97-114-Cont.]

**PRELIMINARY AMENDMENT**

Assistant Commissioner for Patents  
Washington, D.C. 20231

Sir:

Prior to examination on the merits, kindly amend the application as follows:

**IN THE SPECIFICATION:**

Kindly amend the specification as follows:

Page 1,

line 1, add --This application is a continuation application of U.S. Appln. No.  
09/030,447, filed February 25, 1998.-- at the end of the line.

**IN THE CLAIMS:**

Kindly amend the claims as follows:

1. (Amended) A multiple force tool for applying pressure to circuit board components comprising:

first, second and third support channels for supporting first, second and third horizontally extending arms over a circuit board having multiple components;

a plurality of pressure cylinders supported by said horizontally extending arms over each of said components; and

means connected to said pressure cylinders for extending a pressure foot of said cylinders to a position for applying a bonding force against said components providing pressure contact between board components and said circuit board.

Claim 3,

line 3, change "transducers" to --cylinders--.

Kindly cancel claims 5-10.

Kindly insert new method claims 11-15, as follows:

--11. A method for applying a bonding pressure to circuit board components comprising:

supporting first, second and third pressure cylinders over components on said circuit board; and

supplying a source of pressurized air to said pressure cylinders whereby a foot of said pressure cylinders extends to apply a force against said components.

--12. The method for applying pressure to said pressure cylinders according to claim 11 wherein said step of supporting includes a step of positioning said pressure cylinders along said first and second axes to align said cylinder feet with a respective component on said circuit board.

--13. The method for applying pressure to said pressure cylinders according to claim 12 wherein said positioning step includes positioning arms for supporting said pressure cylinder along channels which are located along said axes.

--14. The method according to claim 11 wherein said pressurized air is supplied as a timed pulse wherein said pressure is applied to said components for a fixed duration of time.

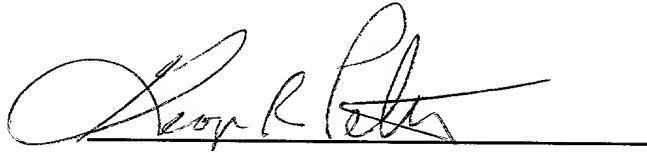
--15. The method according to claim 11 wherein said step of supplying said timed pulse of pressurized air includes regulating the time pulse of air.--

**REMARKS**

Claims 1-4 and 11-15 are pending in the application.

Favorable consideration of the case is requested.

Respectfully submitted,

A handwritten signature in cursive script, appearing to read "George R. Pettit", is written over a horizontal line.

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Date: July 19, 2000

009720-70207960

UNIVERSAL TOOL FOR UNIFORMLY APPLYING A FORCE TO  
A PLURALITY OF COMPONENTS ON A CIRCUIT BOARD

John G. Davis, Allen T. Mays, and James W. Heater

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FIELD OF THE INVENTION

The present invention relates to an apparatus and process for manufacturing electronic circuit boards. Specifically, a tool for applying a force to a component  
10 being bonded to a circuit board is described.

BACKGROUND OF THE INVENTION

Electronic circuit boards are manufactured by mounting components on a printed circuit board. The printed circuit  
15 board includes printed circuit wiring which connects terminals of the components in an electrical circuit. The electrical components on the board often include a heat sink to maintain the electrical component temperature at a safe level. The heat sinks are typically applied to circuit board  
20 components with an adhesive which has good heat transfer characteristics. During the process of bonding the heat sink to a component, the adhesive material is applied to the component or heat sink, and a uniform amount of pressure is applied to the heat sink to establish a high strength bond  
25 with the component. The integrity of the bond is maintained by utilizing a uniform amount of pressure on each heat sink being adhered to the components.

As more than one component might require a heat sink, the heat sinks are individually applied to each component. A  
30 fixture holds the component within a press which applies a force to the heat sink, and must necessarily be configured

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for each individual component as they occupy different positions on the circuit board. To apply heat sinks to different components therefore requires reestablishment of the press position versus the component/heat sink position. Additionally, the heat sink sizes change from component to component, and the amount of pressure applied to different heat sinks, which may be bonded with different adhesives, changes from component to component. These problems have been addressed in the past by employing custom or unique tooling devices to accommodate each heat sink size, as well as circuit board component location on a circuit board, creating inefficiencies in the manufacture of electronic circuit boards.

#### SUMMARY OF THE INVENTION

It is an object of this invention to provide a press for simultaneously applying a force to multiple components and heat sinks on a circuit board.

This and other objects of the invention are provided for by a press which is capable of simultaneously applying force to multiple components of a circuit board assembly. Multiple support channels are provided along a surface of a pressing tool, which support a number of arms which extend over a circuit board. A pressure cylinder is supported on each of the horizontally extending arms and positioned over a respective component which is to receive an applied force. The horizontally extended arms may be positioned along one axis within a respective support channel, while the plurality of pressure cylinders may be positioned along a second axis coincident with the horizontally extending arm supporting the cylinder. Thus, the cylinders may be positioned into

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alignment with a single component on a circuit board, and, when activated, simultaneously apply the required force to a component on the circuit board.

5 In a preferred embodiment of the invention, the pressure cylinders are operated by compressed air supplied by a regulated source of compressed air. A foot valve is connected to the source of compressed air which when operated simultaneously applies an actuating pressure to each of the compressed air cylinders, which results in an extension of  
10 the piston within the cylinders to apply a force to each component located under the cylinders. The amount of pressure as well as the duration of the pressure applied to a component may be accurately controlled ensuring uniformity from circuit board to circuit board.

15

#### DESCRIPTION OF THE FIGURES

Figure 1 is an overall isometric view of the multiple force tool in accordance with a preferred embodiment.

20 Figure 2 illustrates a side view of one of the force-applying air pressure cylinders of the device of Figure 1.

Figure 3 illustrates a second view of the device of Figure 1 which illustrates the positioning of a plurality of pressure cylinders with respect to a circuit board.

25 Figure 4 is another side view of the device of Figure 1.

Figure 5 illustrates the structure for supporting each horizontal arm in a channel of the tool.

Figure 6 is a side section view of Figure 5.

30 Figure 7 is a pneumatic diagram of a pneumatic air controller for operating each of the air cylinders.

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## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to Figure 1, there is shown an isometric view of a multiple force tool for applying a bonding force to multiple components (three of which are shown) on a circuit board 5 supported on a positioning slide 10. When slide 10 is guided into place against the rails of channels 19, 20 and 21, each of the three components shown on circuit board 5 may be appropriately aligned with the ends of a plurality of air cylinders 11, 12, 13 and 14. Cylinders 11 through 14 may be positioned along two axes. The first axis is coincident with the major axes of support arms 6 through 8, and a series of holes 6A, 7A, and 8A along the surface of each of arms 6 through 8 provide various locations in which to mount the respective air cylinder 11-14.

Each of the arms, 6, 7 and 8 is supported within a channel 19 through 21. The horizontally extending arms 6 through 8 are connected to the channel by supports 6B, 7B and 8B. The supports are positionable within the channel to position a respectively supported air cylinder 11-14 along a second axis.

Each of the arms 6 through 8 may have different lengths. The holes 6A, 7A and 8A may also be made of one or more slots, to permit positioning a respective air cylinder along the length of an arm 6, 7 and 8.

The air cylinders 11-14 are operated from a air controller 25 which is connected to a source of compressed air. Compressed air is provided to manifolds 32, 33 provided by hoses 28, 29, which in turn supply compressed air to hoses 35-38 for operating each of the air cylinders 11-14. The manifolds 32, 33 receive air pressure from the air controller 25 and distribute the pressure to each individual

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air cylinder via hoses 35-38.

In this example, two manifolds are provided to accommodate a larger number of air cylinders.

Each of the air cylinders 11-14 includes a flow control  
5 valve 41 through 44. In operation, the flow of compressed  
air is controlled by a foot switch 55 connected by hoses 30,  
31 to the air controller 25 to generate a timed pulse of air  
for operating each of the air cylinders 11-14. A timer 53 of  
the air controller 25 establishes the length of an air pulse  
10 to be applied to each of the air cylinders 11-14 which in  
turn establishes the length of time the piston of each air  
cylinder is extended against a component on circuit board 5  
during a pressing operation.

The pressure level of the air pulse is established by a  
15 control 52 of a regulator. An emergency shut off 50, shuts  
down the air supply to all the cylinders when operated. The  
regulator control 51 regulates the air pressure applied to  
the air controller 25.

Figure 2 illustrates the operation of the device with  
20 respect to one of the air cylinders 13. The air cylinder 13  
in Figure 2 has a piston with a pressure foot 13A which is  
extended as a result of air pressure supplied through the  
flow control valve 43. The pressure foot 13A forces a heat  
sink into pressure contact with a circuit board component  
25 mounted on circuit board 5. An adhesive 2 is shown which  
will bond the heat sink 4 to the circuit board component once  
the heat sink 4 is forced into contact with the circuit board  
component 1.

The quality of the resulting bond is controlled in part  
30 by the magnitude of the force applied by pressure foot 13A,  
as well as the duration of the force. As was noted with

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respect to Figure 1, the value of the applied pressure is controlled by the air controller 25, along with the duration of the applied force. The position of the air cylinder 13 along one axis is established by mounting holes 7A of the horizontally extending arm 7. A pair of screws 45 and 46 hold the air cylinder 13 to the arm 7 so that the pressure foot 13A is positioned along the axis defined by arm 7 aligned with the appropriate component 1.

Figures 3 and 4 illustrate two views of the multiforce device which demonstrate the versatility of the device for circuit boards having different component layouts. As shown in Figure 3, a pair of air cylinders 11 and 12 may be included on the same horizontal arm 6. Horizontal arm 6 and horizontal arm 7 may be positioned along an axis perpendicular to the direction of movement of horizontal arm 8 to align the air cylinders 41-43 with respect to components on circuit board 5. The positioning of arms 6 and 7 is provided for by the channel structure illustrated in Figures 5 and 6. The channel 19 is bounded by two rails 48 and 49. Rails 48 and 49 captivate a lower portion 7C of vertical support 7B. Lower portion 7C includes a slot 60 which maintains the vertical support 7B within the channel 19. A pair of set screws 61 and 62 provide for fixing the vertical support 7B to the rails 48 and 49 when the position of the arm 7 has been established.

The air controller 25 is connected to a compressor (not shown) and derives from the compressor air flow for the required air pulse for operating each of the air cylinders 11-14. A detailed schematic of the air controller 25 is illustrated in Figure 7. Referring to Figure 7, air from the compressor is supplied to a filter/regulator 70 within the

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air controller 25 which filters and regulates the air pressure from the compressor. An emergency power-off valve 71 is actuated by an actuator 50 to turn off the air supply in an emergency. This would result in each pressure foot of  
5 each air cylinder 11-14 being retracted by a spring internal to each air cylinder. A single pilot valve 72 supplies the air pressure in the absence of the operation of the emergency valve to the remaining components of the air controller.

The operation of the air controller for pressurizing  
10 each of the air cylinders 11-14 begins when the foot valve 55 is operated. The air pressure produced from operation of the foot valve 55, is converted into a short pulse of air by a one shot valve 74. A double pilot valve 75 operated from the pulse of air produced by one shot valve 74, to supply air to  
15 regulator 81. The cylinders 11-14 are retracted, when a pulse of air is sent from OR gate 79 to the double pilot valve. The cycle of operating the air cylinders to extend and retract the pressure feet is controlled by a pneumatic timer 77. The pneumatic timer 77 is preset to generate a  
20 time interval following activation of the double pilot valve 75.

The air pulse supplied to regulator 81 is also applied to the input of a timer 77 to begin timing. Once the set time established by control 55 of the timer 77 has elapsed, a  
25 reset signal is sent from the timer to OR gate 79, which, as noted above, resets the double pilot valve 75. The single shot valve 78, in an emergency condition also provides a reset air pulse via OR gate 79 to the double pilot valve 75 for resetting the valve 75. The timer 77 is reset by one  
30 shot valve 80, following the reset of the double pilot valve 75.

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The air controller 25 provides the pulsed air via regulator 81 to each of two manifolds 32 and 33. The outputs from the manifolds 32 and 33 supply air pressure to the flow control valves 41-44 and air cylinders 11-14. A second air regulator 82 may be provided for operating other air cylinders where different air pressures are required.

The flow control valves 41-44 regulate the speed of the air cylinder during extension of the pressure feet of the air cylinders. As such, it avoids any excessive dynamic forces on the component being pressed.

The air controller 25 provides a uniform application of pressure among each of the air cylinders, so that heat sinks, or other components could be bonded to the circuit board in one single operation. Multiple air cylinders avoid having to realign the circuit board in order to apply force to multiple locations on the circuit board, thus saving manufacturing time and assuring a uniform force application.

Positioning of the arms 6, 7 and 8 along each of the channels 19, 20 and 21 may be facilitated by affixing a ruler 88 having position indicia to the sides of the rails of each of the channels. Thus, the vertical supports 6B, 7B and 8B may be accurately positioned for a given component layout on each circuit board 5.

The foregoing description of the invention illustrates and describes one embodiment of the present invention. Additionally, the disclosure shows and describes only the preferred embodiment of the invention, but as aforementioned, it is to be understood that the invention is capable of use in various other combinations, modifications, and environments and is capable of changes or modifications within the scope of the inventive concept as expressed

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herein, commensurate with the above teachings, and/or the skill or knowledge of the relevant art. The embodiment described hereinabove is further intended to explain best mode known of practicing the invention and to enable others  
5 skilled in the art to utilize the invention in such, or other, embodiments and with the various modifications required by the particular applications or uses of the invention. Accordingly, the description is not intended to limit the invention to the form disclosed herein. Also, it  
10 is intended that the appended claims be construed to include alternative embodiments.

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What is Claimed is:

1        1. A multiple force tool for applying pressure to  
2 circuit board components comprising:

3                first, second and third support channels for  
4 supporting first, second and third horizontally extending  
5 arms over a circuit board having multiple components;

6                a plurality of pressure cylinders supported by  
7 said horizontally extending arms over each of said  
8 components; and

9                means connected to said pressure cylinders for  
10 extending a pressure foot of said cylinders to a position for  
11 applying a force against said components.

1        2. The multiple force tool according to claim 1  
2 wherein said horizontally extending arms are positionable  
3 along said channels to vary the location of said pressure  
4 cylinders along a first axis.

1        3. The multiple force tool according to claim 1  
2 wherein said horizontally extending arms include means for  
3 positioning said pressure transducers along a second axis.

1        4. The multiple force tool according to claim 2  
2 wherein said channels include position indicia for  
3 establishing a position coordinate for said pressure  
4 cylinders along said first axis.

1        5. A multiple force tool for establishing a pressure  
2 on circuit board components during manufacture of a circuit  
3 board bearing said components comprising:

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4 first, second, and third channels for supporting a  
5 plurality of horizontal arms, said channels being located  
6 about the periphery of a surface which supports said circuit  
7 board;

8 a plurality of horizontal arms supported in said  
9 channels which extend over said circuit board;

10 a plurality of compressed air pressure cylinders  
11 supported on said horizontal arms, having a pressure foot  
12 which is extendable in response to compressed air to apply a  
13 force on a component of said circuit board located beneath  
14 said pressure foot; and

15 a source of compressed air connected to said  
16 compressed air pressure cylinders, operable in response to a  
17 foot valve for extending said pressure feet against said  
18 circuit components.

1 6. The multiple force tool according to claim 5  
2 wherein said source of compressed air supplies a pulse of air  
3 pressure having a preset duration and magnitude.

1 7. The multiple force tool according to claim 5  
2 wherein said compressed air is supplied through a flow  
3 control valve to said compressed air pressure cylinders for  
4 regulating the speed of extension of said pressure foot.

1 8. The multiple force tool according to claim 5  
2 wherein said source of compressed air comprises:

3 a timer means which operates in response to a  
4 closure of said foot valve to produce a timed pulse of  
5 compressed air to said compressed air cylinders whereby said  
6 pressure feet are extended for a period of time controlled by

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7     said timer.

1           9.    The multiple force tool according to claim 8  
2    further comprising a pressure regulator connected to said  
3    timer means for receiving said pulse of compressed air and  
4    connected to a manifold which supplies said pulse of  
5    compressed air to said compressed air cylinders.

1           10.   The multiple force tool according to claim 9  
2    further comprising a flow control valve connected between  
3    each of said compressed air cylinders and said manifold.

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UNIVERSAL TOOL FOR UNIFORMLY APPLYING A FORCE TO A PLURALITY  
OF COMPONENTS ON A CIRCUIT BOARD

ABSTRACT OF THE DISCLOSURE

5           A multiple force tool for applying pressure to circuit  
          components during a manufacturing operation. A plurality of  
          compressed air pressure cylinders are supported on a  
          plurality of horizontal arms over a circuit board. A  
          pressure foot of each compressed air pressure cylinder is  
10       extendable when an air controller foot switch is depressed.  
          Positioning of each of the cylinders is afforded along two  
          axes, so that the cylinders may be positioned over components  
          which are to be pressed against the circuit board. Heat  
          sinks may be pressed against components located on the  
15       circuit board to bond the heat sinks to the components.

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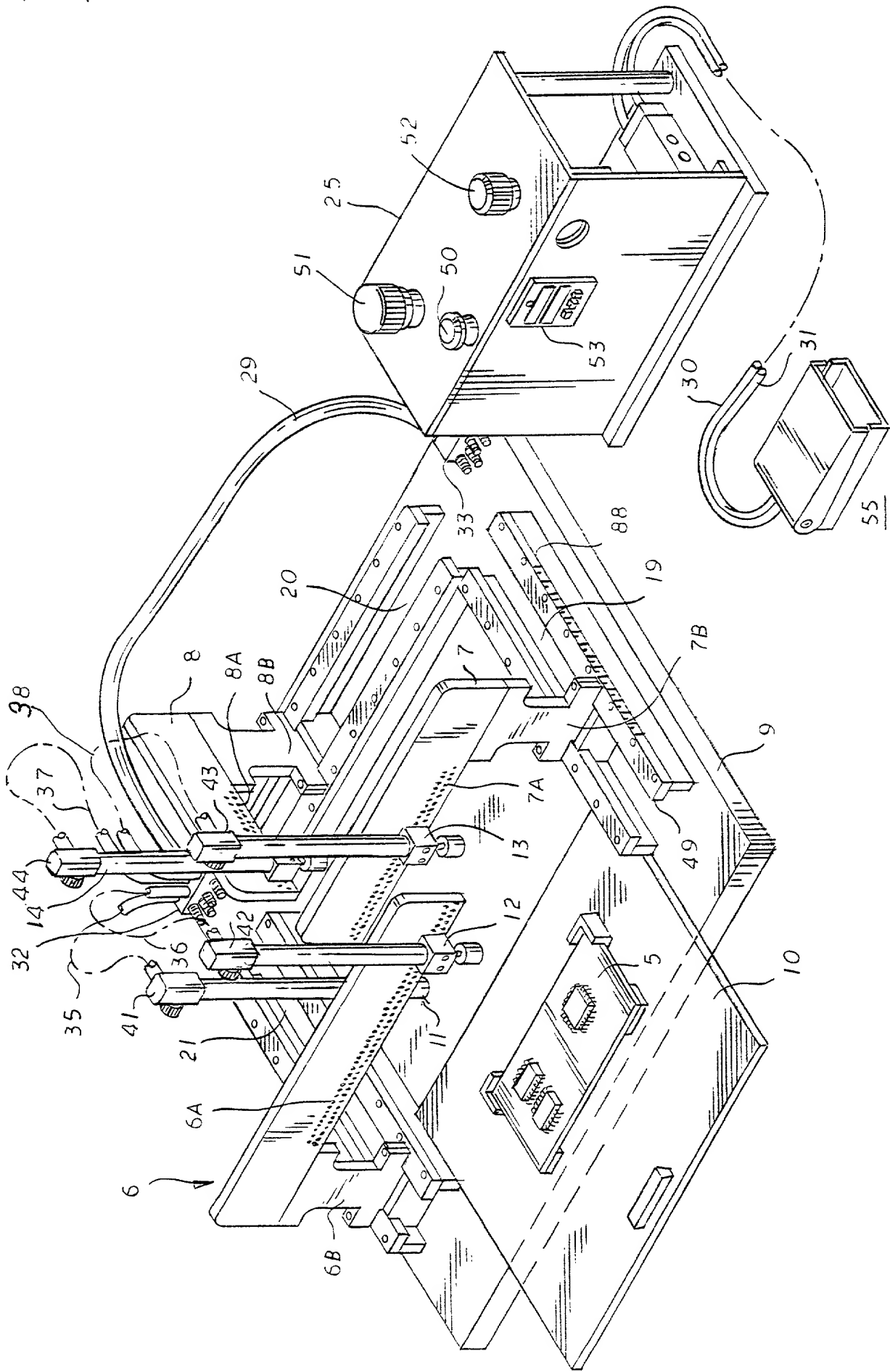


FIG. 1

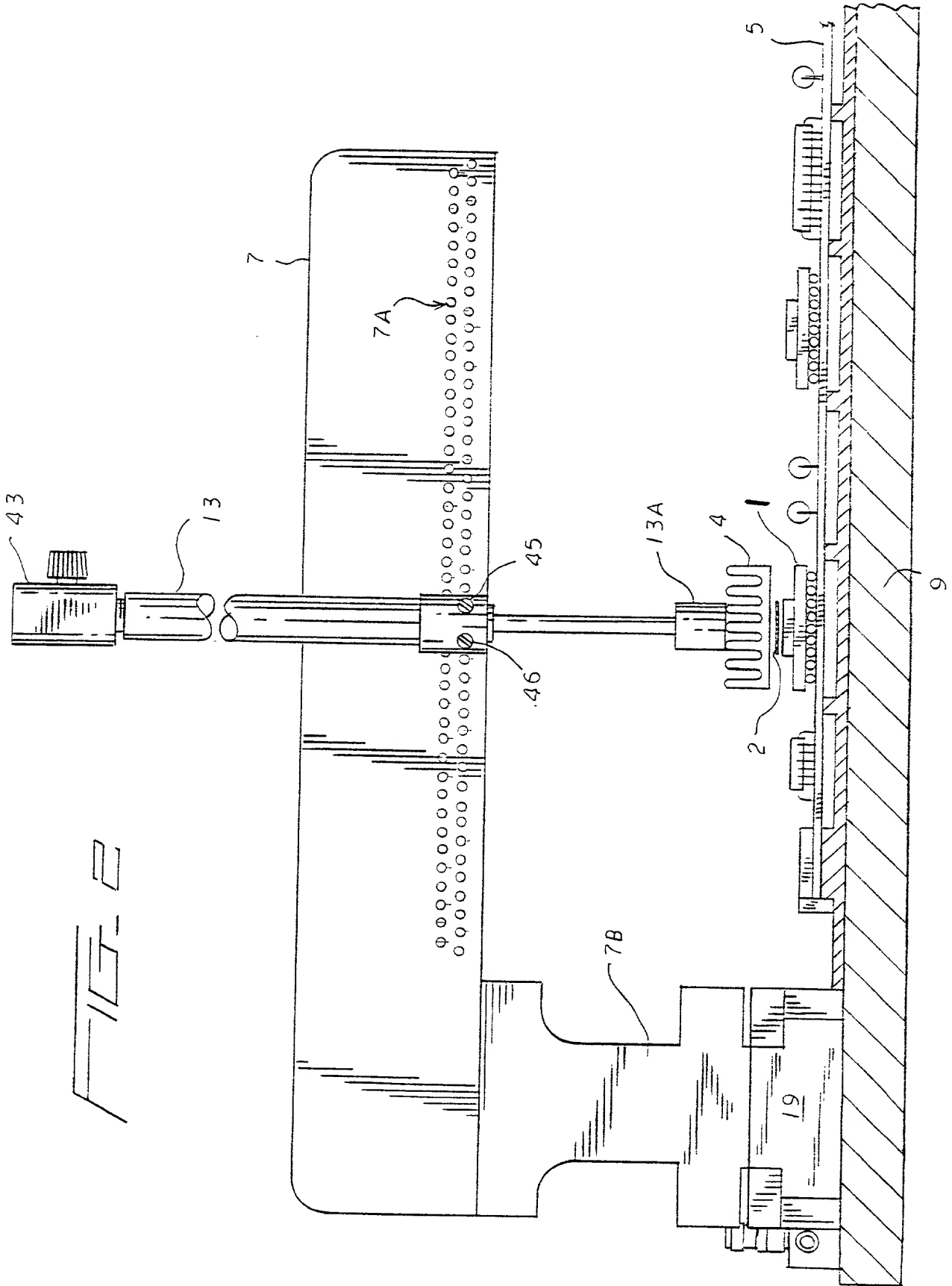
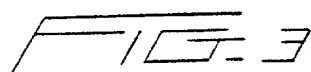


FIG. 2

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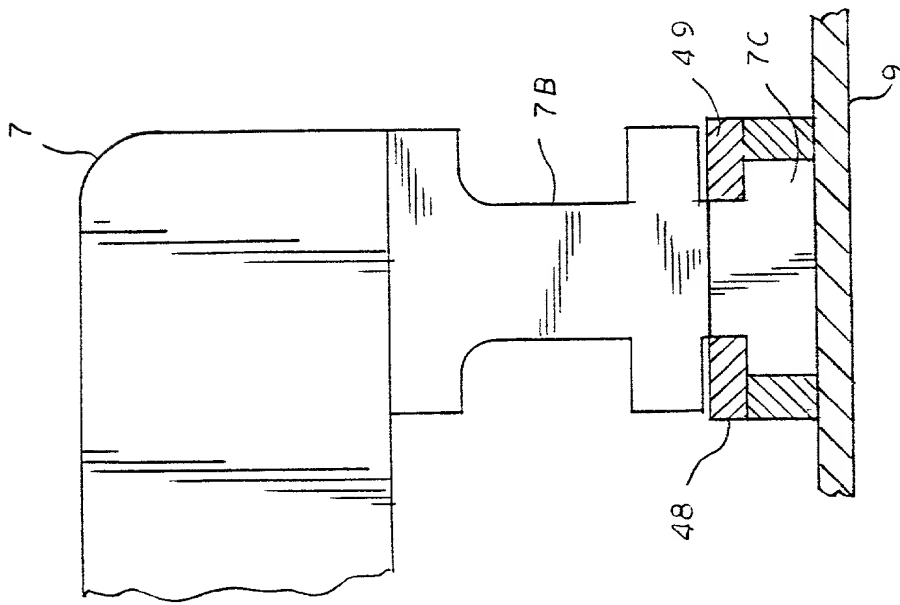


FIG. 6

FIG. 5

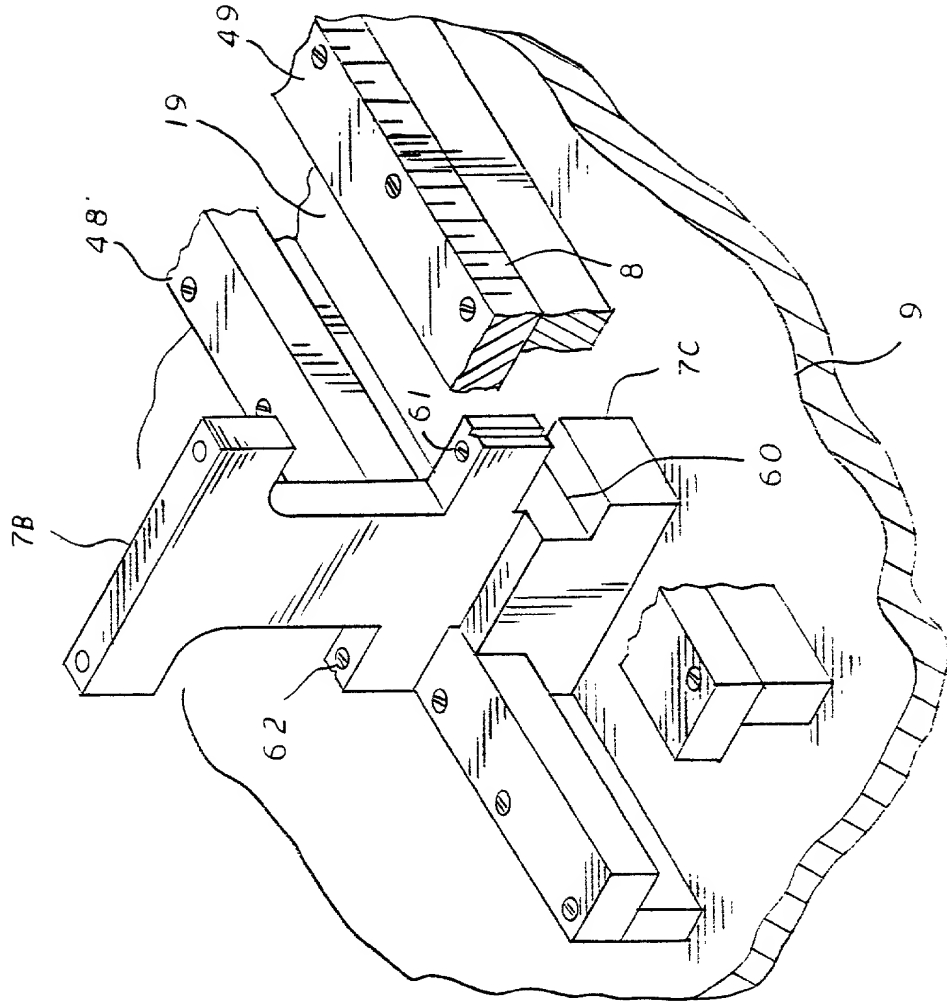
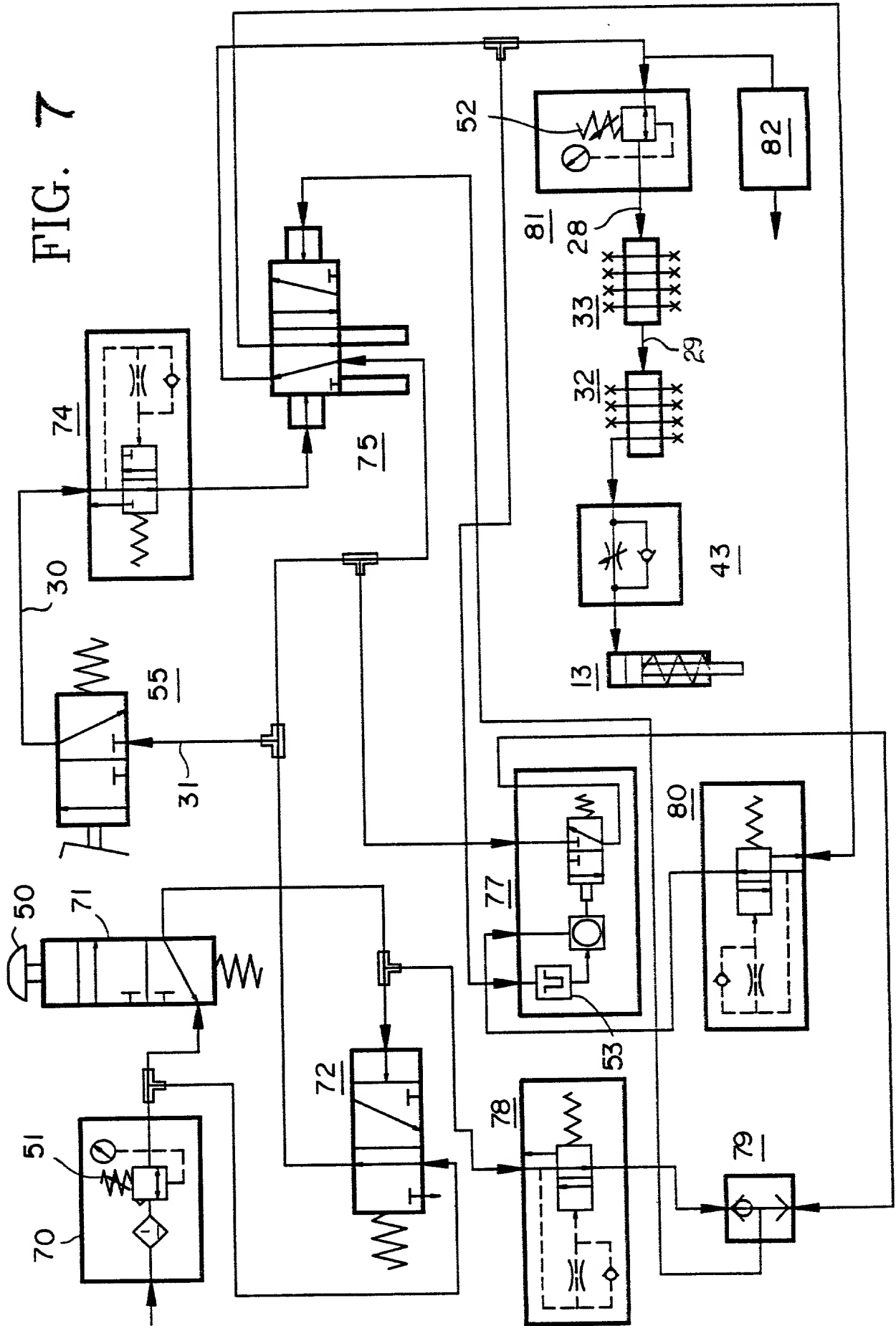


FIG. 7





IBM Docket: EN9-97-114  
Inventor(s): John G. DAVIS et al.

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Sheet 5 of 5

# DECLARATION FOR PATENT APPLICATION

EN9-97-114

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name.

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: **UNIVERSAL TOOL FOR UNIFORMLY APPLYING A FORCE TO A PLURALITY OF COMPONENTS ON A CIRCUIT BOARD**  
the specification of which: (check one)

☒ is attached hereto. ☐ was filed on , as United States Patent Application Serial No. or PCT International Application Number , and was amended on (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 CFR § 1.56(a).

Prior Foreign Application(s): I hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or §365(b) of any foreign application(s) for patent or inventor's certificate listed below, or § 365(a) of any PCT international application which designated at least one country other than the United States of America, listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed:

(Application No.)	(Country)	(Day/Month/Year Filed)	Priority Claimed <input type="checkbox"/> Yes <input type="checkbox"/> No
_____	_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No
_____	_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No
_____	_____	_____	<input type="checkbox"/> Yes <input type="checkbox"/> No

I hereby claim the benefit under Title 35, United States Code § 119(e) of any United States provisional application(s) listed below:

Application No.	Filing Date
_____	_____

I hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s) listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States application in the manner provided by 35 U.S.C. § 112, first paragraph, I acknowledge the duty to disclose material information as defined in 37 CFR § 1.56(a) which occurred between the filing date of the prior application and the national or PCT international filing date of this application:

(U.S. Application Serial No.)	(U.S. Filing Date)	(Status—patented, pending, abandoned)
_____	_____	_____
_____	_____	_____

I hereby appoint the following attorneys and/or agents to prosecute this application and transact all business in the Patent and Trademark Office connected therewith: David L. Adour, Reg. No. 29,604, Lawrence R. Fraley, Reg. No. 26,385, Richard M. Goldman, Reg. No. 25,585, Arthur J. Samodovitz, Reg. No. 31,297, Bernard Tiegerman, Reg. No. 29,707; all of INTERNATIONAL BUSINESS MACHINES CORPORATION; Elliott I. Pollock, Reg. No. 16,906, George Vande Sande, Reg. No. 17,276, Robert R. Priddy, Reg. No. 20,169, Burton A. Amernick, Reg. No. 24,852, Stanley B. Green, Reg. No. 24,351, Richard Wiener, Reg. No. 18,741, Townsend M. Belser, Jr., Reg. No. 22,956; Morris Liss, Reg. No. 24,510, Martin Abramson, Reg. No. 25,787, George R. Pettit, Reg. No. 27,369, Louis Woo, Reg. No. 31,730, Elzbieta Chlopecka, Reg. No. 32,767, Eric J. Franklin, Reg. No. 37,134 and Robert Scott Wales, Reg. No. 39,413; all of POLLOCK, VANDE SANDE & PRIDDY; John E. Hoel, Reg. No. 26,279, Christopher A. Hughes, Reg. No. 26,914, Edward A. Pennington, Reg. No. 32,588; Joseph C. Redmond, Jr., Reg. No. 18,753; all of MORGAN & FINNEGAN, L.L.P.

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements are made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under 18 U.S.C. § 1001 and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

Full name of sole or first inventor: James Westcott Heater

Inventor's Signature: James Westcott Heater

Date: 2/20/98

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☒ See next page for additional inventors

# DECLARATION FOR PATENT APPLICATION

Page Two

Full name of second joint inventor (if any): Allen Thomas Mays

Inventor's Signature Allen Thomas Mays Date 2-20-98

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Full name of third joint inventor (if any): John Gillette Davis

Inventor's Signature John Gillette Davis Date 2/20/98

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Full name of fourth joint inventor (if any): \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

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Citizenship \_\_\_\_\_

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Full name of fifth joint inventor (if any): \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence Address \_\_\_\_\_

Citizenship \_\_\_\_\_

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Full name of sixth joint inventor (if any): \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

Residence Address \_\_\_\_\_

Citizenship \_\_\_\_\_

Post Office Address \_\_\_\_\_

Full name of seventh joint inventor (if any): \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

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Full name of eighth joint inventor (if any): \_\_\_\_\_

Inventor's Signature \_\_\_\_\_ Date \_\_\_\_\_

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